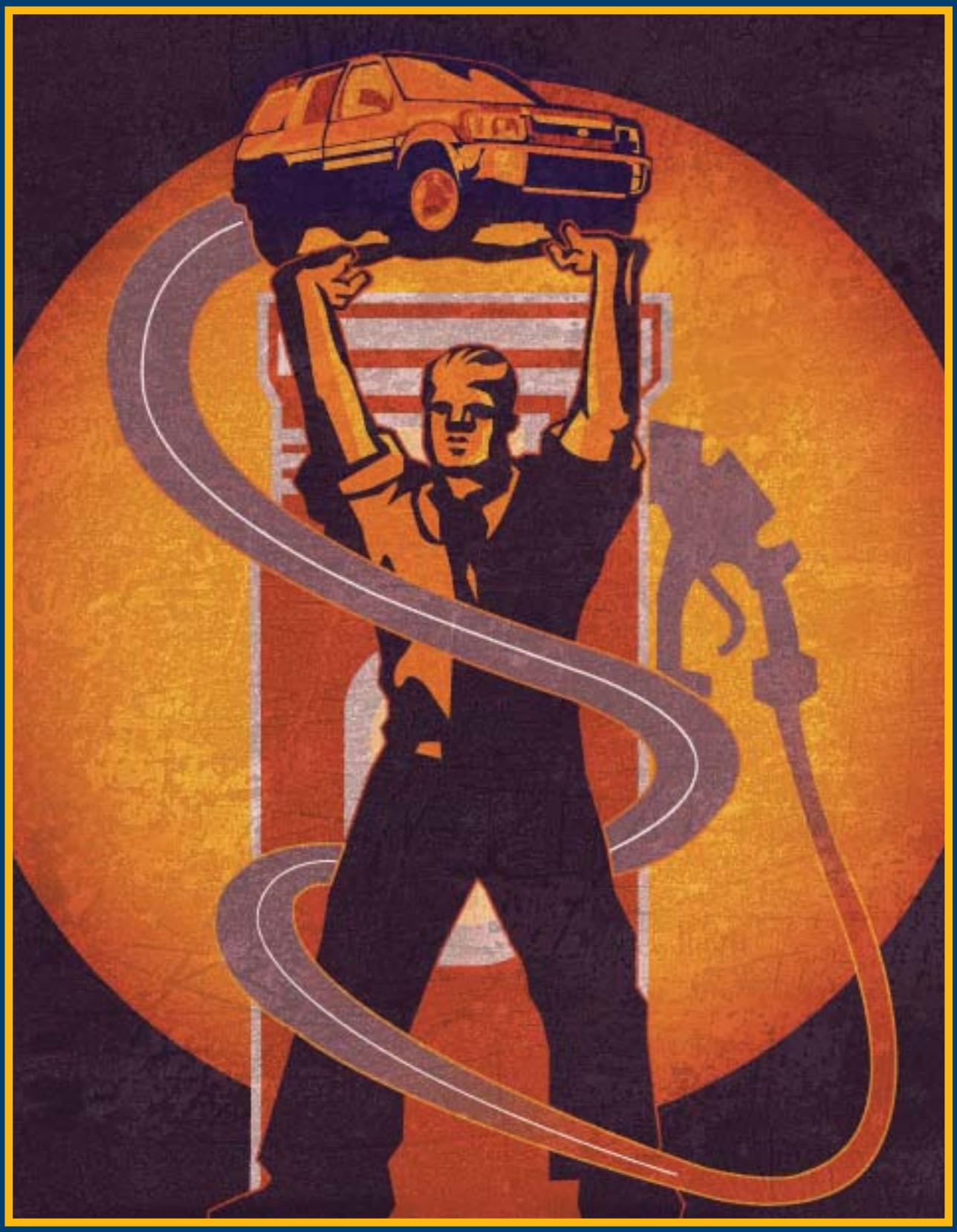
FLEX YOUR MUSCLE

with Clean Energy Exercises



A WORKBOOK FOR MIDDLE SCHOOL STUDENTS

Fuel Cell Car

Solar Tracking Panels

A Sustainable Home

Fuel Cell Bus and Car

Close-up of Electrolyzer

Hydrogen Pump

Hydrogen Storage

This workbook was created by SunLine Transit Agency and the Schatz Energy Research Center at Humboldt State University with funding from the South Coast Air Quality Management District and others. Our goal is to introduce you to the wonderful world of sustainable energy. We hope you come to understand energy concepts and to appreciate our energy resources. At the same time, have fun and stay connected to the Earth! *Answers to all problems are on page 11.*

WHO WE ARE

Located in the Coachella Valley of Southern California, SunLine is a leader in clean transportation. The agency was the first in the world to convert all its diesel buses overnight to buses powered by clean natural gas. Today SunLine operates vehicles that run on natural gas and hydrogen, as well as other clean fuel mixtures. We believe one day soon you will be driving cars powered by the same clean fuels.

The Schatz Energy Research Center, located on California's rugged North Coast, has the mission of promoting the use of clean and renewable energy. Our small group of environmental engineers created the nation's first fuel cell powered car, whose only byproduct is pure water. At Schatz, we're preparing for a sustainable energy future by working on renewable energy projects that use our specialty fuel cells for clean, back-up power.

This zero-emission fuel cell bus runs on clean, abundant hydrogen made at SunLine.

Automobile Emissions

Visit the following Environmental Protection Agency website: http://www.epa.gov/otaq/05-autos.htm. Read the first page, which is about automobile emissions. Then fill in the blanks in the story using the words below.

carbon dioxide
lungs
byproducts
nitrogen
heart disease
hydrocarbons
polluter
ozone
combustion
eyes
engine

Although it seems that emissions from an individual car are small, the millions of cars on the road make the personal automobile the single greatest __ __ __ __ __ __ __ __.

The power to move a car comes from burning fuel in an __ __ __ __ __ __.
The __ __ __ __ __ __ __ __ __ __of combustion produce pollution.

The following pollutants are byproducts of combustion: hydrocarbons, nitrogen oxides, carbon monoxide, and carbon dioxide.

__ __ __ __ __ __ __ __ __ __ __ __ result when fuel molecules in the engine do not burn or burn only partially. Nitrogen oxides (NOx) are formed when __ __ __ __ __ __ __ __ and oxygen atoms from the air react under the high pressure and temperature conditions in an engine.

Nitrogen oxides and hydrocarbons both help to form __ __ __ __ __, a major component of smog. Ozone irritates the __ __ __ __, damages the __ __ __ __ __, and aggravates respiratory problems. It is our most widespread urban air pollution problem.

Carbon monoxide is a product of incomplete __ __ __ __ __ __ __ __ __ __. Carbon monoxide reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with __ __ __ __ __ __ __ __ __ __ __.

__ __ __ __ __ __ __ __ __ __ __ __ __ __does not directly impair human health, but is a "greenhouse gas" that traps the earth's heat and contributes to global warming.

America's first street-legal fuel cell car runs on hydrogen made from solar power.

Car Calculations

What kind of car does your family own? Find out how many mpg your car gets by visiting the following website: www.fueleconomy.gov/ feg/ findacar.htm. Then you can estimate how many gallons of gasoline you use each year, assuming your family drives 5,000 miles a year. It's easy! Just follow the example:

Car: ***Hundai Accent***
Miles Per Gallon (mpg): ***36 mpg (highway)***

Your Car: _____
Miles Per Gallon:_____

$$\left(\frac{\text{5,000 miles}}{\text{year}}\right) \times \left(\frac{\text{1 gallon}}{\text{36 miles}}\right) = \frac{\text{139 gallons}}{\text{year}} \qquad \left(\frac{\text{5,000 miles}}{\text{year}}\right) \times \left(\frac{\text{1 gallon}}{\text{\_\_ miles}}\right) = \frac{\text{\_\_\_ gallons}}{\text{year}}$$

Next, calculate how much money your family spends on gas for that car in one year. Again, just follow the example. *(Note: you may want to check the price of gasoline near you to be more accurate.)*

$$\left(\frac{\text{139 gallons}}{\text{year}}\right) \times \left(\frac{\text{\$1.25}}{\text{gallon}}\right) = \frac{\text{\$173.75}}{\text{year}} \qquad \left(\frac{\text{\_\_\_ gallons}}{\text{year}}\right) \times \left(\frac{\text{\$\_\_\_\_}}{\text{gallon}}\right) = \frac{\text{\$\_\_\_\_\_}}{\text{year}}$$

Now, calculate how many pounds of carbon dioxide (CO_2) are produced in one year from the use of your car. 20 pounds of CO_2 are released for every gallon of gasoline burned.

$$\left(\frac{\text{139 gallons}}{\text{year}}\right) \times \left(\frac{\text{20 lbs. } CO_2}{\text{gallon}}\right) = \frac{\text{2780 lbs. } CO_2}{\text{year}} \qquad \left(\frac{\text{\_\_\_ gallons}}{\text{year}}\right) \times \left(\frac{\text{20 lbs. } CO_2}{\text{gallon}}\right) = \frac{\text{\_\_\_\_ lbs. } CO_2}{\text{year}}$$

Car Challenge

(Use a separate piece of paper if necessary.)

Part 1:

Using the calculation techniques we practiced above, *calculate:*

1) dollars spent

2) CO_2 produced in a car that gets 45 mpg. Now do the same for a car that gets 18 mpg. Assume the cars travel 5,000 miles each year. a) How much money do you save if you use the car that gets more miles per gallon? b) How many pounds of CO_2 do you avoid putting into the air?

Part 2:

In 1995 there were 179,659,000 cars and light trucks on the road in America. Assume that each vehicle got an average of 20 miles per gallon. *Calculate:*

1) how many gallons of gasoline and how much money the nation would save if every car and light truck got 1 mpg more and drove 5,000 miles that year.

SunLine uses solar panels to make hydrogen.

Amps, Volts & Watts

Watts (W) is a unit of power, just like horsepower. With cars we use horsepower, but with electrical appliances we use watts. These are measures of how much "umph" is behind an activity. A 60W light bulb draws three times as much power as a 20W light bulb. A 60W incandescent light bulb is brighter than a 20W incandescent light bulb.

Amps, or current, is a measure of electron flow rate.

Volts is a measure of pressure behind the electrons.

amps x volts = watts

So, 2 amps x 12 volts = 24 watts. This is how we write that: 2A x 12V = 24W

Your house has 120-volt electricity coming through the wall outlet.
Fill in the blanks below for the power needed by these appliances:

blow dryer . . . . . **12A x 120V= _____ W**

flashlight bulb . . . . . **0.25A x 3V= _____ W**

toaster . . . . . **7A x 120V= _____ W**

electric drill . . . . . **12.5A x 120V= _____ W**

blender . . . . . **2A x 120V= _____ W**

small radio . . . . . **0.1A x 120V= _____ W**

refrigerator . . . . . **4A x 120V= _____ W**

computer . . . . . **1.5A x 120V= _____ W**

The Schatz Stack-in-a-Box® is a portable fuel cell that uses hydrogen to generate electricity.

Kilowatts

A thousand watts is a kilowatt (kW): 1,000W = 1 kW

Fill in the blanks below.

3,000 W = _____ kW	**2,500 W = _____ kW**
1,800 W = _____ kW	**2,000 W = _____ kW**
500 W = _____ kW	**750 W = _____ kW**
1,200 W = _____ kW	**100 W = _____ kW**
35,820 W = _____ kW	**42,700 W = _____ kW**
12,500 W = _____ kW	**65,000 W = _____ kW**
167,500 W = _____ kW	**210,750 W = _____ kW**

Based on your answers from page 5, match each appliance to its power.

blow dryer	**0.84 kW**
toaster	**0.18 kW**
electric drill	**1.44 kW**
blender	**0.48 kW**
refrigerator	**0.24 kW**
computer	**1.5 kW**

A fuel cell, installed and at work!

Watt-hours

Many people get confused between kilowatts and kilowatt-hours. But you don't need to be confused. See for yourself. It's easy!

One watt for one hour is one watt-hour: 1W x 1h = 1Wh. Also, one kilowatt for one hour is one kilowatt-hour.

1 kW x 1hr = 1kWh

Watt-hours and kilowatt-hours are measures of the amount of energy consumed by an appliance.

Power x Time = Energy

Let's consider watts and watt-hours. A 40 W light bulb that is on for 2 hours consumes 80 watt-hours. This is different from having a light bulb that requires 80 watts. 80 watts is the amount of power a light bulb might use, and 80 watt-hours is the amount of energy a 40 W light bulb uses if it is on for 2 hours. How many watt-hours are consumed when:

you play a 10W radio for 2 hours:	**10 W x 2 h = _____Wh**
you run a 30W light for 3 hours:	**_____W x _____h = _____Wh**
your 1500W microwave runs for 0.25 hours:	**_____W x _____h = _____Wh**
your 60W stereo runs for 2 hours:	**_____W x _____h = _____Wh**
your 250W computer runs for 3 hours:	**_____W x _____h = _____Wh**
your 80W TV runs for 1.5 hours:	**_____W x _____h = _____Wh**

Coachella Valley windmills produce enough electricity to power the desert.

Renewable Energy

Visit the following website: http://www.energy.ca.gov/education/renewableroad/index.html and read the "Discover California's Energy" section under each major heading. Then complete the crossword puzzle on the next page.

There are five kinds of renewable energy: SOLAR, WIND, GEOTHERMAL, BIOMASS and HYDROELECTRIC.
This puzzle deals with the first three.

D = *down* **A** = *across*

SOLAR

The _ _ _ (6D) has been an energy source since the beginning of time. When we hang laundry outside to dry in the sun we are using the sun's heat to do _ _ _ _ (19A).

Plants need the sun's light to make _ _ _ _(18D).
This process is called _ _ _ _ _ _ _ _ _ _ _ _ _ (8D). Photo means " _ _ _ _ _ " (4D), and synthesis means "to _ _ _ _ _ _ _" (7A) two different things together to make something new.

The sun can be used to _ _ _ _ (13A) water in homes and businesses. Sunlight can even _ _ _ _ (17D) food! We can change the sunlight to electricity by using solar photovoltaic cells. They are called "_ _ _" (16D) for short. Photo means light and "voltaic" is a word for electricity.

Electrical energy from solar cells can be used directly in a home. Small PV cells are used on many small _ _ _ _ _ _ _ _ _ _ _ (15A), like calculators, as well as space satellites, billboards or an emergency roadside telephone.

WIND

Wind is another kind of energy that makes things work. You can't see the wind, but when it blows you can feel it push against your _ _ _ _ (24D).

_ _ _ _ _ _ _ _ _ (25D) use wind energy to push their way through the water. Farmers have been using wind energy for many years to pump _ _ _ _ _ (22A) from wells. Today, wind is used to make electricity.

Blowing wind spins the blades on a wind turbine – just like a large toy _ _ _ _ _ _ _ _ (21D). The spinning _ _ _ _ _ _ (23A) turn a generator that makes electricity.

California has many areas that are _ _ _ _ _ (26A) most of the year. In these areas, it is often windier during the _ _ _ _ _ _ (27A).

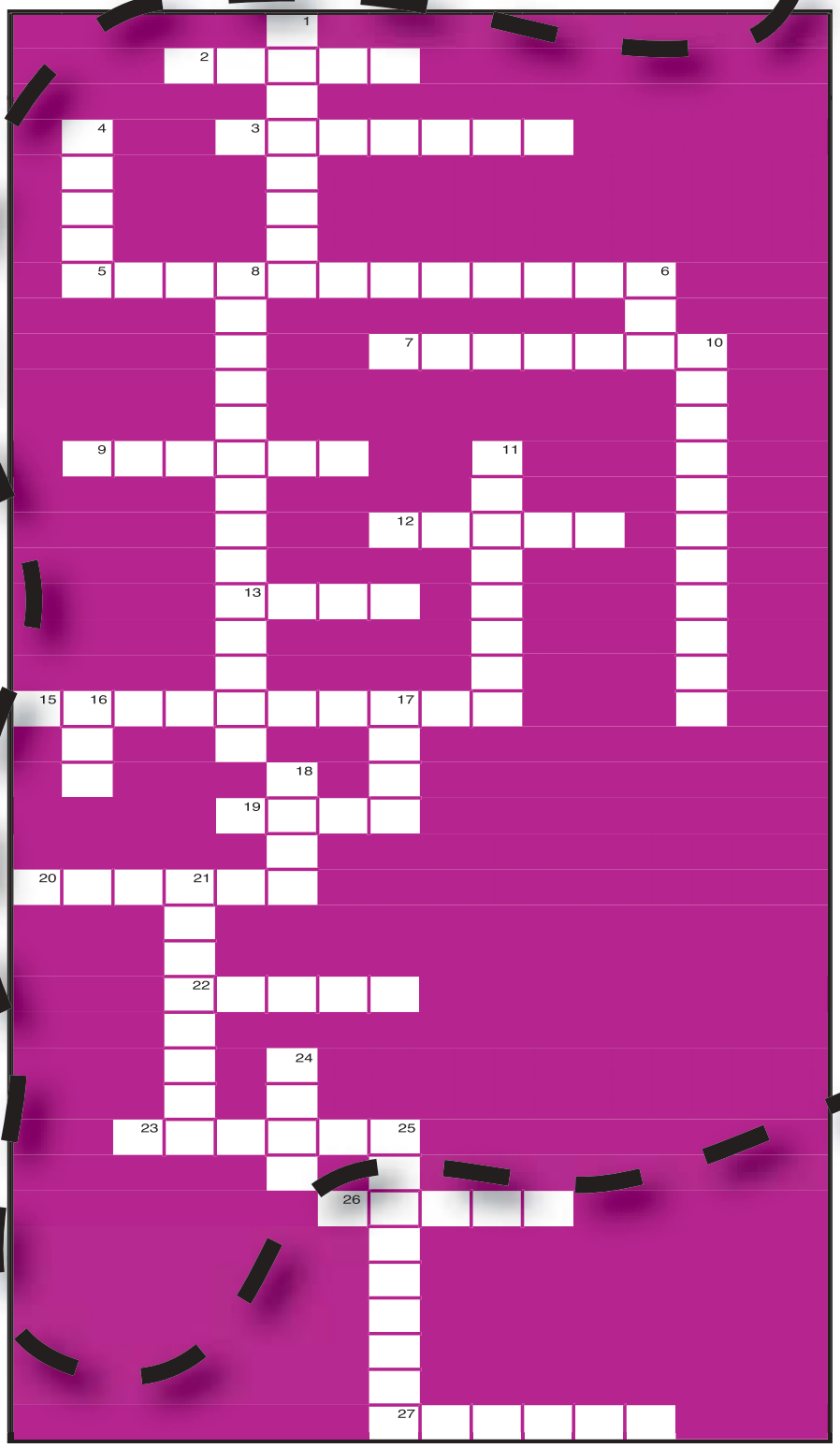
GEOTHERMAL

Geothermal means "_ _ _ _ _ (12A) heat." Deep, underground, water sometimes comes close to the hot rock and gets so hot it becomes _ _ _ _ _(2A). This hot water can reach _ _ _ _ _ _ _ _ _ _ _ _ (5A) of more than 300 degrees Fahrenheit, which is hotter than _ _ _ _ _ _ _ (3A) water.

When this hot water comes up through a crack in the earth, it's called a _ _ _ _ _ _ (9A) or hot spring. Some of this hot water can be _ _ _ _ _ _ (20A) up from the ground to heat buildings.

In some areas of California there is so much steam and hot water that it is used to generate _ _ _ _ _ _ _ _ _ _ _ _(10D) . The hot steam or water is pumped from below ground to a power plant where it's used to turn _ _ _ _ _ _ _ _ (11D) to make electricity.

Forty-six of California's 58 counties have some type of geothermal _ _ _ _ _ _ _ _(1D).



This hybrid fuel cell bus doesn't pollute at all!

Word Search

Can you find the words?

They might go up, down, diagonally, or backwards!

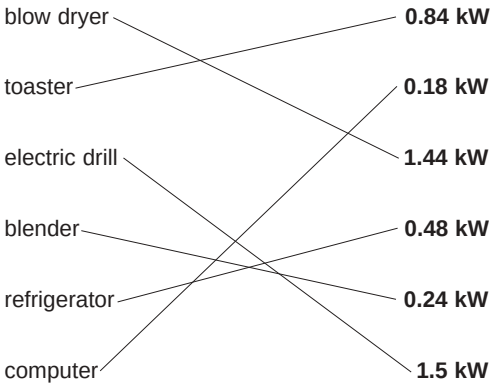
A	H	B	R	N	I	D	S	P	L	F	E	K	W	C	N
H	L	D	E	H	B	R	J	H	T	U	R	B	I	N	E
Y	X	T	Z	C	G	E	O	T	H	E	R	M	A	L	O
D	Y	A	E	A	D	J	L	K	I	L	O	W	A	T	T
R	E	V	U	R	M	T	K	D	W	C	V	R	T	P	Y
O	S	O	X	Q	N	V	I	A	G	E	Z	P	Y	H	U
E	C	L	E	A	N	A	I	R	D	L	F	J	L	Y	K
L	Z	T	M	W	E	R	T	T	Y	L	W	I	N	D	U
E	I	S	I	O	P	A	B	I	O	M	A	S	S	R	S
C	D	F	S	G	H	J	L	K	V	Z	X	C	V	O	B
T	N	M	S	O	L	A	R	Q	W	E	N	E	R	G	Y
R	E	R	I	T	D	M	C	V	F	R	F	B	B	E	G
I	N	H	O	Y	M	P	J	U	K	I	L	U	O	N	P
C	Z	A	N	Q	X	S	S	W	C	D	E	S	E	V	F
R	B	G	S	T	N	H	Y	M	J	U	K	I	O	L	L
P	R	F	V	R	E	N	E	W	A	B	L	E	T	G	S

ALTERNATIVE FUELS
BUS
CAR
CLEAN AIR
EMISSIONS
ENERGY
FUEL CELL
HYDROGEN
SOLAR
TURBINE
VOLTS
AMPS
KILOWATT
RENEWABLE
WIND
GEOTHERMAL
BIOMASS
HYDROELECTRIC

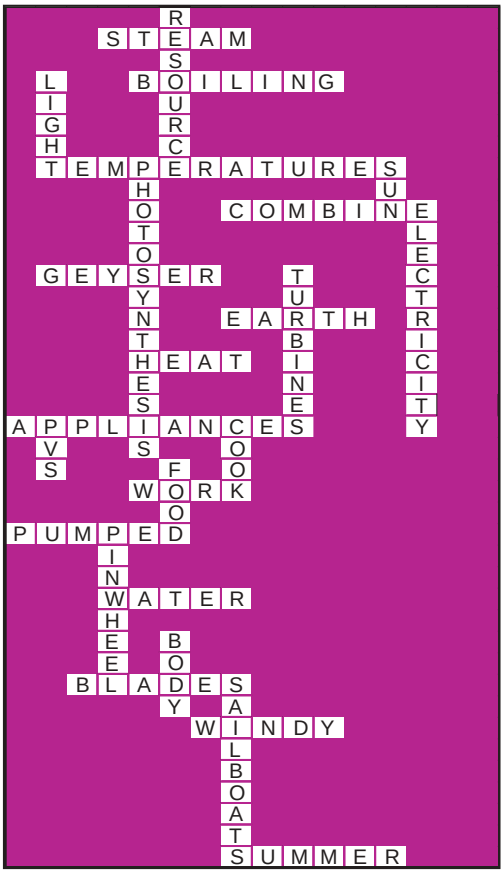
Answers

KILOWATTS

3,000 W =	3 kW	2,500 W =	2.5 kW
1,800 W =	1.8 kW	2,000 W =	2.0 kW
500 W =	0.5 kW	750 W =	0.75 kW
1,200 W =	1.2 kW	100 W =	0.1 kW
35,820 W =	35.82 kW	42,700 W =	42.7 kW
12,500 W =	12.5 kW	65,000 W =	65 kW
167,500 W =	167.5 kW	210,750 W =	210.75 kW



RENEWABLE ENERGY



AUTO EMISSIONS

Although it seems that emissions from an individual car are small, the millions of cars on the road make the personal automobile the single greatest **POLLUTER**.

The power to move a car comes from burning fuel in an **ENGINE**.
The **BYPRODUCTS** of combustion produce pollution.

The following pollutants are byproducts of combustion: hydrocarbons, nitrogen oxides, carbon monoxide, and carbon dioxide.

HYDROCARBONS result when fuel molecules in the engine do not burn or burn only partially. Nitrogen oxides (NOx) are formed when **NITROGEN** and oxygen atoms from the air react under the high pressure and temperature conditions in an engine.

Nitrogen oxides and hydrocarbons both help to form **OZONE**, a major component of smog. Ozone irritates the **EYES**, damages the **LUNGS**, and aggravates respiratory problems. It is our most widespread urban air pollution problem.

Carbon monoxide is a product of incomplete **COMBUSTION**. Carbon monoxide reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with **HEART DISEASE**.

CARBON DIOXIDE does not directly impair human health, but is a "greenhouse gas" that traps the earth's heat and contributes to global warming.

WATT-HOURS

you play a 10W radio for 2 hours:	10	W x	2	h =	20 Wh
you run a 30W light for 3 hours:	30	W x	3	h =	90 Wh
your 1500W microwave runs for 0.25 hours:	1500	W x	.25	h =	375 Wh
your 60W stereo runs for 2 hours:	60	W x	2	h =	120 Wh
your 250W computer runs for 3 hours:	250	W x	3	h =	750 Wh
your 80W TV runs for 1.5 hours:	80	W x	1.5	h =	120 Wh

CAR CHALLENGE

PART 1

$\left(\frac{5{,}000\ \text{miles}}{\text{year}}\right) \times \left(\frac{1\ \text{gallon}}{45\ \text{miles}}\right) = \frac{111\ \text{gal}}{\text{year}} \Big/ \frac{111\ \text{gal}}{\text{year}} \left(\frac{\$1.85}{\text{gal}}\right) = \$205.35/\text{yr} \Big/ \frac{111\ \text{gal}}{\text{year}} \left(\frac{20\ \text{lbs}\ CO_2}{\text{gal}}\right) = \frac{2{,}220\ \text{lbs}}{CO_2/\text{yr}}$

$\left(\frac{5{,}000\ \text{miles}}{\text{year}}\right) \times \left(\frac{1\ \text{gallon}}{18\ \text{miles}}\right) = \frac{278\ \text{gal}}{\text{year}} \Big/ \frac{278\ \text{gal}}{\text{year}} \left(\frac{\$1.85}{\text{gal}}\right) = \$514.30/\text{yr} \Big/ \frac{278\ \text{gal}}{\text{year}} \left(\frac{20\ \text{lbs}\ CO_2}{\text{gal}}\right) = \frac{5{,}560\ \text{lbs}}{CO_2/\text{yr}}$

a) $514.30 – $205.35 = $308.35 saved by driving car getting 45 mpg

b) 5,560 lbs CO_2 – 2220 lbs CO_2 = 3,340 lbs CO_2 avoided if driving car getting 45 mpg

PART 2

$\left(\frac{5{,}000\ \text{miles}}{\text{year}}\right) \times \left(\frac{1\ \text{gallon}}{20\ \text{miles}}\right) = \frac{250\ \text{gallons}}{\text{year}}$ $\quad$ $\left(\frac{5{,}000\ \text{miles}}{\text{year}}\right) \times \left(\frac{1\ \text{gallon}}{21\ \text{miles}}\right) = \frac{238\ \text{gallons}}{\text{year}}$

20 mpg = 250 gal/yr
21 mpg = 238 gal/yr
} 250 – 238 = 12 gallons saved/car
12 gal yr (179,659,000 cars) = 2,155,908,000 gal. gas saved

$\frac{250\ \text{gal}}{\text{year}} \left(\frac{\$1.85}{\text{gal}}\right) = \$462.50/\text{yr}$ (20 mpg) $\quad$ $\frac{238\ \text{gal}}{\text{year}} \left(\frac{\$1.85}{\text{gal}}\right) = \$440.30/\text{yr}$ (21 mpg)

$462.50 – $440.30 = $22.20 (179,659,000 cars) = $3,988,429.800 saved

WORD SEARCH

A	H	B	R	N	I	D	S	P	L	F	E	K	W	C	N
H	L	D	E	H	B	R	J	H	T	U	R	B	I	N	E
Y	X	T	Z	C	G	E	O	T	H	E	R	M	A	L	O
D	Y	A	E	A	D	J	L	K	I	L	O	W	A	T	T
R	E	V	U	R	M	T	K	D	W	C	V	R	T	P	Y
O	S	O	X	Q	N	V	I	A	G	E	Z	P	Y	H	U
E	C	L	E	A	N	A	I	R	D	L	F	J	L	Y	K
L	Z	T	M	W	E	R	T	T	Y	L	W	I	N	D	U
E	I	S	I	O	P	A	B	I	O	M	A	S	S	R	S
C	D	F	S	G	H	J	L	K	V	Z	X	C	V	O	B
T	N	M	S	O	L	A	R	O	W	E	N	E	R	G	Y
R	E	R	I	T	D	M	C	V	F	R	F	B	B	E	G
I	N	H	O	Y	M	P	J	U	K	I	L	U	O	N	P
C	Z	A	N	Q	X	S	S	W	C	D	E	S	E	V	F
R	B	G	S	T	N	H	Y	M	J	U	K	I	O	L	L
P	R	F	V	R	E	N	E	W	A	B	L	E	T	G	S

AMPS, VOLTS & WATTS

blow dryer	12A x 120V= 1440 W
flashlight bulb	0.25A x 3V= 0.75 W
toaster	7A x 120V= 840 W
electric drill	12.5A x 120V= 1,500 W
blender	2A x 120V= 240 W
small radio	0.1A x 120V= 12 W
refrigerator	4A x 120V= 480 W
computer	1.5A x 120V= 180 W

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